Korea's R&D Activities in Clean Energy Technology

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1. Introduction

The structure of energy demand and supply in Korea has been greatly changed along with the rapid economic growth and industrialization since the 1960's. In 1994, total primary energy consumption in Korea was 137 million TOE, which is seven times as much as that of 1970. Energy demand has increased at a rate higher than that of national economic growth for past several years.

The guasi-total penury in domestic energy resources compel Korea to resort to foreign imports for its energy demand. This foreign dependence showed increasing trend during the recent years(97% in 1998). Rational utilisation of energy and promotion of renewable energy sources have thus become the two major energy policy directions in Korea.

Since Korea became the member of OECD in 1996, environmental concern has drawn growing attention of the public and private sectors to meet the target for CO_2 emission reduction.

Since 1994, the Korean Government commissioned race for energy R&D activities including clean energy technologies, such as clean coal technologies, oil desulfurisation and flue gas treatment in order to mitigate the emission of many kinds of air pollutants. More than 50 clean energy projects were initiated and some of them are still in progress. The 10-year R&D plan in energy technology, established in 1997 for the purpose of comprehensive national energy technology development, includes new & renewable energy development and energy conservation technology as well as clean energy technology.

2. RaCER

2. 1 Objective and Function

To establish the R&D management system for development of technologies related to energy and resources by integration of steps from planning to evaluation	To promote the utilization and dissemination of the developed technologies	To strengthen the interaction between government and private industry through cooperation and information exchange

History

Dec. 1987	Promulgation of New & Renewable Energy Development Act.
Aug. 1988	Inauguration of the "New & Renewable Energy Development Section" in KEMCO.
Sep. 1989	Enlargement of the "New & Renewable Energy Development Section" to the "New & Renewable Energy Development Center"
Dec. 1992	Reorganization of the "New & Renewable Energy Development Center" into "R&D Management Center for Energy and Resources(RaCER)"

Major functions and activities

- Survey of technological demands
- R&D fund raising and allocation
- R&D project management from selection to evaluation
- Dissemination of developed technologies
- Education, Technical consulting and training
- International cooperation
- Promotion of research on energy policies

2. 2 Organization

The organization of RaCER is shown in Figure 1. The Director of RaCER with the help from Council on R&D for Energy Resources takes the responsibility of planning, management and evaluation of energy related projects. Planning Department provides the other two departments with administrative support such as planning, information collection and distribution, international cooperation, budget, and etc. R&D Department I in charge of the management on new & renewable energy, clean energy and natural resources technologies, shares the burden of management with R&D Department II responsible for management on energy efficiency, conservation

technologies and electric technologies.

Total number of employee of RaCER are 44 including 9 Ph.D's, 9 Masters in engineering or science and 17 energy license holders.

3. R&D on the Clean Ene rgy Technology

3. 1 Objective

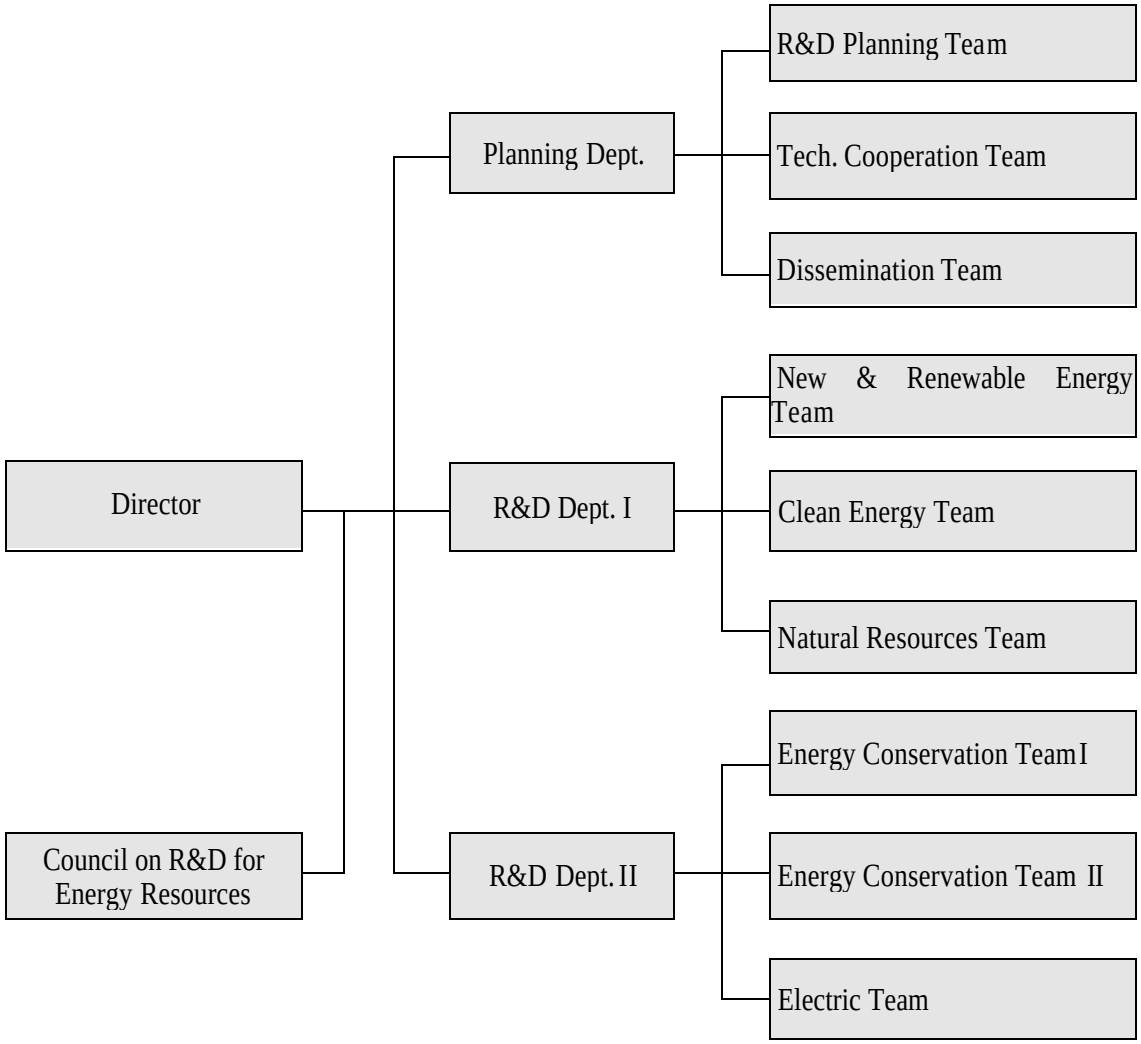


Figure 1. RaCER Organization Chart

- In order to conserve clean environment and meet environmental regulations, the development of clean energy technology should be required to reduce air pollutants causing acid rain and global warming, which are subjected to increase with the amount of fossil fuels used.

- In order to meet the regulations and duties imposed by Green Round and OECD membership, the development of clean energy technology can not be dispensible. In particular, the independency of the technologies in energy and environment area is expected to help the domestic industry with lifting the competitive edge.

- Furthermore, as the eventual level of CO_2 emission allowance will be in the same range as those for the advanced countries of OECD, the clean energy technology capable of reducing CO_2 emission must be developed in a short period of time.

3. 2 Scope of the R&D

- Development of technologies for the reduction of air pollutants (SO_X, NO_X, dust particle and CO_2 emissions)

  - Technologies for coal combustion with low pollution and high efficiency
  - Technologies for desulfurization of crude oil and upgrading of heavy oil
  - Technologies for removing air pollutants, especially for separation and utilization of CO_2, from fossil fuel flue gas

- Major programs

  - 11 programs have been selected taking the precedents of the advanced countries as well as the size of the domestic application into account. Among them, 5 programs have been selected as high-priority ones. 5 high-priority programs are Fluidized-bed combustion, Coal-ash utilization, Combustion flue gas treatment, petroleum & New catalyst technology, CO_2 separation & recovery technology.

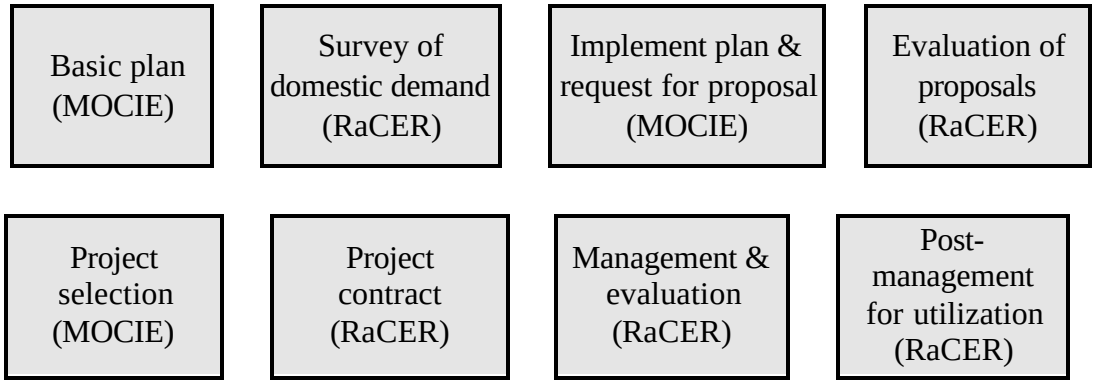
- General programs

  - Regeneration of spent petroleum catalyst, microbe desulfurization

3. 3 Outline of Project Support System

- Execution : MOCIE (Ministry of Commerce, Industry and Energy)

- System



- Implementing Organization

To diversify the source of energy, Korean government established the "New & Renewable Energy Development Center" in September 1989 based on the "New & Renewable Energy Development Promotion Act" enacted in December 1987. To reduce the increasing rate of energy demand, this center was also acknowledged as a responsible agent for R&D management of energy efficiency and conservation technologies (EE&C) following the "Rational Energy Utilization Act" as revised in 1991. The center was restructured to "R&D Management Center for Energy and Resources (RaCER)" as an affiliated organization of KEMCO(Korea Energy Management Corporation) in December 1992. The Organizational Structure of Energy Technology R&D in Korea is shown in Figure 2.

3. 4 Strategy

- Establishment of strategy per annum for the accomplishment of objectivies of the program
- Organization of Expert Committee for high priority program .
- Strengthening the cooperative ties with the countries in possession of advanced clean energy technology such as the US., Australia, Canada
- Fortification of academic research program for production of the experts in energy field
- Enhancement of cooperation between the institutes concerned for more efficiency in investment

3. 5 Financial Support

During the period of 1994-1998, Korean government invested public funds of 17,432 million Won. along with private investment of 4,402 millon Won. to the development of clean energy technology. The public financial sources are mainly from the "Special Accounts for Projects of Energy and Resources". The amount of financial support by categories is shown in Table 1.

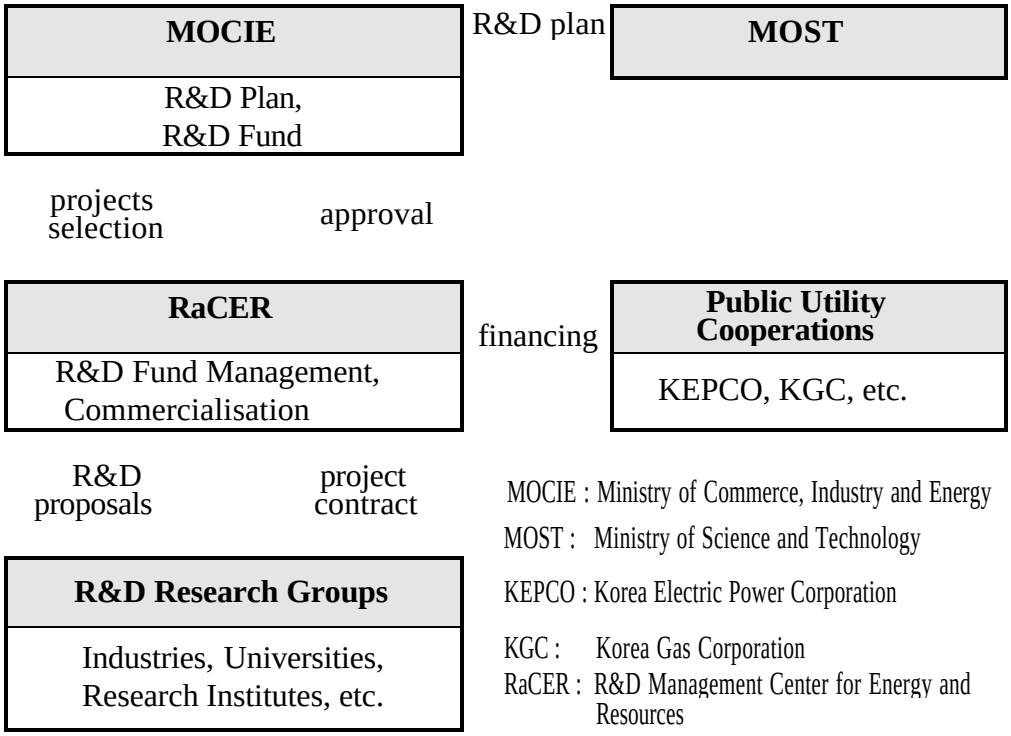


Figure 2. The Organizational Structure of Energy Technology R&D

Table 1. Financial support for Clean Energy Technology

Categories of Projects	No. of Tasks	Project fund (million Won)		
		Public fund	Private investment	Total
1) fluidized bed combustion	8	2,449	582	3,031
2) combustion treatment	13	3,742	1,341	5,083
3) new catalyst technology	1	145	72	217
4) clean coal technology	13	5,469	1,343	6,812
5) petroleum desulfurisation	8	3,306	976	4,282
6) CO_2 related technology	15	2,321	88	2,409
Total	58	17,432	4,402	21,834

(1US$ = about 1,200 Won)

3. 6 Achievements

A total of 324.4 billion Won has been invested in 1,718 energy technology R&D projects (204.6 billion Won from the government sector, and 119.8 billion Won from the private sector).

Table 2. Investment in Energy Technology R&D

Area	Period	Projects	Investment (100 million Won)		
			Government	Private Sector	Total
Conservation	1992-1998	783	1,042	528	1,570
New & Renewable Energy	1988-1998	717	770	608	1,378
Clean Energy	1994-1998	152	174	44	218
Natural Resources Technology	1995-1998	66	60	18	78
Total	-	1,718	2,046	1,198	3,244

Renewable Energy Technology

Renewable energy supply accounted for 1.03% (1,715,673 TOE) of total energy supply as of the end of 1998. Solar thermal hot-water units and industrial waste incineration system have been commercialized and are being disseminated. Certain areas of photovoltaic energy have passed the basic research phase and are beginning to see the light for commercialization, as can be seen from the expansion of use of photovoltaic power system in small island regions.

Energy Conservation Technology

Out of the 212 R&D tasks completed by the end of 1997, 27 have entered utilization stage resulting in an expectation of 60 billion won per annum from import substitution effect. The 27 tasks include high-efficiency electronic ballast, industrial catalyst combustion equipment, and high-efficiency refrigerators.

Clean Energy Technology

Korea is at the initial stage of technology development for clean energy, and is currently conducting basic research.

Natural Resources Technology

This programme pursues a stable supply of essential minerals, the enhancement of the added value of domestic minerals and stones, and technology development for domestic coal utilization.

3.7 Direction of R&D Policy

- Mid-and long-term plan aimed at meeting the requirements of environmental regulations
  - Upgrading of current domestic regulations to the standards of advanced countries
  - Development and utilization schedule set for the time when the upgraded regulations come into force

- Establishment of the action plan for the most efficiency
  - Differentiation between the high-priority and the general programs
  - Optimization of each action plan

- Maximization of the impact of technology development with emphasis on systemization of unit technology
  - Development of comprehensive support system by total planning
  - Development of the engineering technology for practical implementation of the developed technology

- Step-by-step development plan based on a technical tree
  - Understanding of foreign National Programs

- Suggestion of policy direction based on the analysis of the R&D plans by Expert Committee
  - Establishment of priorities

- Enhancement of utilization of the developed clean energy technology

  - Expansion of 'Energy Technology Demonstration Projects' by inclusion of the

resuluts from clean energy development

4. The 10-year R&D Plan for Energy Technology

- To reflect a comprehensive R&D plan for energy technology in National Basic Energy Plan (1997-2006) by integrating three Respective Energy R&D Plans, i.e. energy conservation, renewable energy development and clean energy development.
- To formulate a more effective strategy for energy technology R&D on the basis of the past achievements and experiences

4.1 Background

4. 2 History of Energy R&D in Korea

1970's

The realization of importance of energy technology acquired through the two Oil Crisis, provided a momentum for launching the first R&D plan to raise the capabilities in energy technology. Led by KIST (Korea Institute of Science and Technology), R&D renewable in alternative energy such as solar thermal and wind power, was initiated.

1980's

With the stabilization of the international energy market, Korea carried out its R&D efforts with emphasis on energy supply-side technology including renewable energy development.

In accordance with 'New & Renewable Sources and Energy (NRSE) Development & Promotion Act' come into force in December 1987, the government established the "Basic Plan for NRSE Technology R&D" (1988-2001), the major goal of which was to supply 3% of total energy demand from renewable energy sources by 2001.

1990's

As there are increasing moves to restrict energy consumption worldwide, particularly following the Climate Change Convention, importance of energy conservation technology and clean energy technology has become emphasized.

For energy conservation, the government devised 'Five-year R&D Plan for Energy Conservation (1992-1996)', the major goal of which was to decrease energy consumption elasticity to below 1.0.

With the entry into force of the Climate Change Convention in March 1994, the government established 'Five-year R&D Plan for Clean Energy (1994-1998)'. The major goal of the plan was to secure clean combustion technology for fossil fuels to reduce air pollutants, especially CO_2 emission.

4. 3 High-priority Programs

Clean energy technology: 5 high-priority programs

Out of 11 R&D programs in the field of clean energy development, 5 programs have been selected as high-priority ones on the basis of the survey result on R&D trend and status in advanced countries as well as the possibility and the impact of successful development.

These 5 high-priority programs include Fluidized-bed combustion, Coal-ash utilization, New catalyst development for desulfurization and upgrading of heavy oil, Combustion flue gas treatment technology, CO_2 emission control technology. The summary of the high-priority technologies by categories is shown in Table 3.

There are active international joint-researches now under way in the area of clean energy technology in response to the Climate Change Convention, and Korea is trying to strengthen cooperative ties with the countries such as the U.S., Australia, and Canada which have clean energy technology in hand.

4. 4 Future Direction of Energy Policy

Feasibility of the objectives of energy technology R&D plan

Feasibility of an energy technology R&D plan in terms of domestic technological level, availability of funds, and likelihood of utilization, will play a main role at the stage of selection.

Table 3. Summary of the high-priority technologies.

Field	Program	Outline	Aim of the project
Coal	Fluidized Bed Combustion	Development of FBC technology - Low pollutant - High efficiency - Wide range of fuel . low grade coal . industrial waste	· Operation optimization for atmospheric circulating fluidized bed combustion · Utilization of PFBC technology
	Coal-ash Utilization	Development of new application of coal ash - environment benign - value addition by re-use construction material	· Mass utilization technology by separation and reforming (effective utilization : > 60%)
	Combustion flue gas treatment	Reduction of air pollutants - SO_X, NO_X - dust particles	· Utilization of high efficient technology for reducing SO_x, NO_x and dust particles
Petroleum	New catalyst technology	Use of clean petroleum - development of new catalyst - evaluation	· Development of new catalyst - deep hydrodesulfurization of crude oil - upgrading of heavy oil
CO_2 Emission	Separation and recovery of CO_2	Development of high efficient CO_2 redution process - absorption - biological fixation - photoelectrochemical conversion	· Development of solution for the Climate Change Convention - Reduction of CO_2 emission · Separation · Recovery

Selection & concentration in respect of the effect of investment

The areas of energy technology R&D, so far, have been usually selected on a bottom-up basis through demand surveys. In consequence, the selected R&D project had a tendency to focus on an unit technology that can be utilized and disseminated in a short period of time. Through the process, Korea has enjoyed success to some extent in laying and expanding the foundation for energy technology development.

In the future, a mid- and a long-term investment strategies on a top-down basis must be employed for a R&D project selection. This top-down method requires the analysis not only on technological capabilities but also on economic impacts such as the spin-off effects and the experiences of advanced countries.

Improvement of infrastructure in energy technology R&D

In order to enhance the efficiency of technology R&D projects, improvement of the infrastructure for energy technology should be carried out in parallel. This infrastructure comprises international cooperation programs, information systems as well as human resources and facilities.

Procedures to promote the utilization of new technology

As the results of the first stage of R&D activities are generated, an institutional procedure or support system will be required to make the results utilized in a practical system.

More efficient R&D management system

The current R&D management system will be improved in two ways as follows; First, a task force team for each of 5 high-priority programs, responsible for overall R&D planning, research and sub-project management, will be organized and operated for better program management as a whole. Second, the objectivity and the clearness of the evaluation procedure will be secured by forcing the quantification of feasible project goals, for example in terms of thermal efficiency or money-saving effect.

Appendix

The list of the ongoing projects for clean energy technology development

Fluidized Bed Combustion

Project title	Agency
Study of Alkali metal removal process in PFBC	Ajou Univ.
Development of essential element technology for pressurized fluidized bed combustor (Solids recycle system technology)	KAIST
The Development of PFBC Operating Technology at Bench Scale	KIER
The Development of CFBC and Emission Control Technology	KIER
High Efficiency High Temperature and High Pressure Filter Media/Unit for PFBC	KIER

Combustion Flue Gas Treatment

Project title	Agency
Developement of Manganese Oxide DeNox Catalysts and Processes for SCR(Selective Catalytic Reduction) System	KOPEC
The Development of De NO_X/SO_X Process Using of Plasma Reactor	KIER
The Development of Flue Gas Desulfurization Process with $Mg(OH)_2$	KIER
The Development of Photocatalysis/Electron beam Hybrid Reactor System for De NO_X/SO_X	KIER
The research on De NO_X/SO_X Technology in Furnace with SNCR (Selectivity Non Catalytic Reduction)	KIER
The research on Low NO_X Combustion Technology in Furnace System	Samsung Heavy Industry Co.

Clean of Petroleum

Project title	Agency
The Catalyst Evaluation and Recycling Technics for the RFCC	LG-Caltex co.
Recovery of Pt and Pd from the Spent Petroleum Catalysts by H_2SO_4 Dissolution	KIGAM
The Development of Preperation Process from Residual Oil by Partial Oxidation Methode	KIER

Clean of Coal

Project title	Agency
Study on Removal of Unburned Carbon in Fly Ash by Multi Air Classifier	KIGAM
Synthesis of long effective fertillizer by use of fly-ash from reaction of fly-ash, KOH and mineral ashed	TaeBaek Deop & trans, Inc.
A Study on the Manufacture of Light Weight Aggregates for Structual Concrete from Fly-ash	KIGAM
A Study on Utilization of Coal Fly Ash as Soil Stabilizing Materials	Ssangyong Co.
The Development of High Efficiency Compact Hybrid Fabric Filter and Coating Filter Media	KIER
The Development of High Volume Fly-ash Concrete	DongAh Co.
The Development of Absorbent Using High Carbon Coal Fly Ash	KIER

CO_2 Utilization Technology

Project title	Agency
Development of Biological Carbon Dioxide Fixation Process	KAIST
Separation and Utilization Technologies of Carbon Dioxide in Flue Gas for Industrial Uses	KIER
The Development and Optimization Studies on the MeOH Synthesis by Hydrogenation of Carbon-Dioxide and MTO (Methanol To Olefin) process.	Kyeunghee Univ.

Development of New Catalyst of Carbon Dioxide Reforming of Methane to Suppress Coke Deposition	Pohang Univ.
A Study on the Hybrid Process for Energy Efficient Recovery of CO_2	KAIST
Homogeneous Hydrogenation of CO_2 to Form Oxygenate Compounds	KIST

Petroleum New Catalyst

Project title	Agency
The Development of Dissel HDA Catalyst	Hanwha Co.
The Development of Novel High-Performance RFCC Catalyst	KAIST